



U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

Dear Crash Data Researchers/Users:

Thank you for choosing crash data from the National Highway Traffic Safety Administration (NHTSA) for your research or other use. The information contained in this motor vehicle crash report is collected, maintained and distributed in accordance with Public Law 89-564. In accordance with this Public Law, NHTSA is required not to release any case information until completion of quality control procedures. These procedures include a review of the case material to extract all names, licenses and registration numbers, non-coded interview material, non-research related researcher comments in the margins, non-factual data, and the production number portion of the vehicle identification number (VIN).

If you requested NHTSA to query its database files in order to identify a specific crash, then that query was made using non-personal descriptors you provided for use in our search. This motor vehicle crash may have been identified from a data search and matches the general, non-personal descriptors you provided, but we cannot confirm that this is the specific crash report you requested.

If you have any questions with regard to the above procedures, please contact the Field Operations Branch, Crash Investigation Division, National Center for Statistics and Analysis at 202-366-4820. Again, please be advised that we cannot confirm that this is the case that you have specifically requested nor can we certify the information to be correct.

*** *** ***



AUTO SAFETY HOTLINE
(800) 424-9393
Wash. D.C. Area 366-0123

TRANSPORTATION SCIENCES CENTER
ACCIDENT RESEARCH GROUP

██████████ 1992

Division of Arvin/Calspan
Buffalo, New York 14225

CALSPAN ON-SITE VEHICLE DEFECT INVESTIGATION

CALSPAN CASE NO. 92-5

VEHICLE - 1992 FORD AEROSTAR XL MINIVAN

LOCATION - ██████████ S.C.

ACCIDENT DATE - ██████████ , 1992

Contract No. DTNH22-87-C-27169

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMERS

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the precrash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 92-5	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Calspan On-Site Vehicle Defect Investigation Vehicle - 1992 Ford Aerostar Minivan Location - ██████████ SC		5. Report Date: ██████ 1992	
		6. Performing Organization Code	
7. Author(s) Accident Research Group		8. Performing Organization Report No.	
9. Performing Organization Name and Address Transportation Sciences Center Accident Research Group Division of Arvin/Calspan P.O. Box 400 ██████████ 14225		10. Work Unit No. ██████████	
		11. Contract or Grant No. DTNH22-87-C-27169	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. Type of Report and Period Covered Technical Report Accident Date ██████/92	
		14. Sponsoring Agency Code	
15. Supplementary Notes On-site investigation of an alleged vehicle defect that involved a 1992 Ford Aerostar minivan. The upper rear control arm separated from its mount which resulted in lateral instability and subsequent rollover of the vehicle.			
16. Abstract This report focuses on an alleged defect of the upper rear control arm on a 1992 Ford Aerostar minivan. A 3/16" diameter roll pin fractured which allowed a 5/8" diameter stud to separate from the cast iron upper control arm. As a result, lateral stability of the rear axle was lost and the van rotated rapidly in a clockwise direction and overturned on the interstate roadway. During the rollover sequence, two adult female occupants (unrestrained) were ejected from the vehicle and sustained fatal injuries. The driver and her right front passenger were both wearing the active 3-point lap and shoulder belt systems. They remained in their respective positions and sustained minor (AIS-1) severity injuries. An unrestrained rear seat occupant also remained in the vehicle and sustained minor injuries. Our inspection of the vehicle confirmed that the upper rear control arm had separated from its left lateral mounting point which resulted in lateral instability of the rear axle. The rear tires contacted and abraded the inner wheel housings and the upper coils of the rear coil springs. The 5/8" diameter stud had separated from the control arm as the 3/16" diameter roll pin fractured. The roll pin positioned and retained the stud in the case iron arm. The control arm was removed from the vehicle and shipped to NHTSA for further inspection and a NTSB metallurgical review. This report is included as Attachment B.			
17. Key Words Rear upper control arm separation Fractured roll pin Side-over-side rollover		18. Distribution Statement General Public	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 39	22. Price

TABLE OF CONTENTS

	<u>Page No.</u>
Summary	1
Selected Prints	4
Slide Index	24
Appendix A: Police Accident Report	26
Appendix B: Metallurgical Report	31

CALSPAN ON-SITE VEHICLE DEFECT INVESTIGATION

CALSPAN CASE NO. 92-5

VEHICLE - 1992 FORD AEROSTAR XL MINIVAN
LOCATION - [REDACTED] SC

SUMMARY

This crash resulted from an alleged defect of the upper control arm in the rear suspension of a 1992 Ford Aerostar XL extended 4 x 2 minivan. The Aerostar was a rental vehicle and was occupied by five adult occupants en route to a conference in [REDACTED] on [REDACTED], 1992, at 1810 hours. The vehicle was manufactured in [REDACTED] 1992 and was identified by the following V.I.N.: 1FMDA31U6NZ[REDACTED]. The Aerostar had an odometer reading of approximately 3,400 miles and a gross vehicle weight rating (GVWR) of 5,260 lbs.

The seating configuration of the Ford Aerostar consisted of three rows of seats with a seven passenger rating. The front captain's chairs were occupied by the 26 year old female driver (66.5", 130 lbs.) and a 27 year old male right front passenger with a height of 64" and weight of 140 lbs. Both front row occupants were properly restrained by the manual 3-point lap and shoulder belt systems. A 26 year old female with a height of 60" and weight of 105 lbs. was seated in the center position of the second seat. She was not wearing the manual 3-point lap and shoulder belt system. The third seat was occupied by a 26 year old female (63", 115 lbs.) who was seated in the left outboard position, and a 27 year old male (70", 150 lbs.) who was seated in right outboard position. The third seat occupants were not restrained, although manual 3-point lap and shoulder belts were available.

The manual 3-point lap and shoulder belt systems for the second and third rows of bench seats were designed to be manually detached from the seat frames to facilitate removal of the seats. The outboard seating position of the second and third bench seats were fitted with 3-point safety belts. Each 3-point continuous loop belt webbing was fitted with two latchplates. One was a conventional latch (buckle) designed for easy latching and unlatching by the seat occupant to use when buckling up when riding in the vehicle. The other latch was for detachment of the safety belt anchorage from the seat frame to facilitate removal of the vehicle's bench seat. This latch was located on each outboard side of the bench seat and is unlatched with the use of a key. Although the rear (third) seat occupants were not wearing the active restraint systems, the outboard belt anchorage latchplates were found unlatched at the time of our inspection. The second seat's belt anchorages were properly latched but the safety belts were not worn.

The five occupants of the vehicle had luggage that averaged a driver estimated weight of 25 lbs. apiece. There were also 3-4 boxes of paper products (reports) in the van that weighed approximately 35 lbs. apiece. The total occupant and cargo weight of the van was approximately 890 lbs. at the time of the crash. The combined occupant and cargo weight was approximately 900 lbs. under the vehicle's maximum GVWR limit.

The Ford Aerostar was traveling in a southerly direction on the left (inboard) travel lane of an interstate roadway at a driver estimated speed of 65 mph. The interstate roadway consisted of two lanes in each direction which were divided by a wide depressed grass median. The dry concrete road surface was 23'4" wide and was bordered by a 10'2" paved west (right) shoulder and a 4'2" wide east shoulder. The smooth road surface was straight and level and was in good condition with no defects. The posted speed limit was 65 mph.

The driver stated that the van started to shake and subsequently rotated rapidly in a clockwise direction. An unidentified truck driver who was following the Ford Aerostar, told the tow truck operator that he noted something fall from the rear of the van as the Aerostar began to fishtail within the travel lane. The vehicle

subsequently initiated a side-over-side rollover sequence, leading with its left side. The vehicle rolled along the left edge of the roadway an unknown number of quarter turns before coming to rest on its roof. There was no evidence at the accident scene (i.e., gouges, paint transfers) to support the number of rolls. Damage to the van was extensive; however, the passenger compartment remained intact with all side doors remaining closed. The rear fiberglass door (liftgate) fractured at the upper corners during the rollover and partially opened. The latch for the rear door remained closed. The right front door glass, the sliding left side glass, the left rear quarter glazing and the backlight glass shattered during the rollover sequence. The driver estimated the number of overturns at 4.5 while her male passengers estimated 6-7 complete rolls. Based on the damage to the vehicle, the van probably completed 2.5-4.5 rolls.

During the rollover sequence, the unrestrained female passengers were completely ejected from the vehicle through the left rear quarter window opening onto the concrete road surface. The female passenger who was seated in the second seat sustained severe injuries to the head and expired at the scene. The other ejected passenger who was seated in the third seat, was transported to a local hospital where she expired several hours following the crash due to multiple injuries. The belted driver of the Ford Aerostar attempted to brace against the steering wheel rim during the rollover sequence. Her left hand probably separated from the wheel and contacted the ground during the rollover which resulted in abrasions of her left hand (AIS-1), a fracture of the left ring finger (AIS-1), an avulsion of a fingernail (AIS-1), and abrasions of the left elbow (AIS-1). She also sustained abrasions of her left knee (AIS-1) from contact with the lower instrument panel area and pain of the neck and upper back. The driver remained in her seat during the rollover. She reported that the left front door window was fully opened prior to the event.

The right front occupant loaded the active belt system during the rollover and sustained a right rib fracture (AIS-1) and abrasions of the right neck (AIS-1). The right rear (third seat) male occupant was not restrained and remained in the vehicle during the rollover. He sustained several minor abrasions (AIS-1) and refused medical treatment. The driver and right front

passenger were transported to a local hospital where they were treated for their injuries and released.

Following the crash, a local tow operator noted some debris on the roadway and retrieved the objects from the travel lanes. The objects consisted of a large diameter steel stud, a rubber bushing, and a large washer. He stated that these objects were located several hundred feet behind the final rest position of the van. The tow operator suspected that these components had separated from the vehicle's suspension. He inspected the undercarriage of the Aerostar and noted the rear upper control arm had separated from the left mounting point.

The rear mounted upper control arm (Ford Part No. F09A-5500-AA) was cast iron, molded in a Y-configuration with three mounting points to the vehicle. The control arm was attached to the rear axle housing, right of the differential, with a 5/8" diameter x 4" long bolt that threaded into the left side mounting bracket of the control arm. The control arm extended forward of the rear axle and attached to a frame crossmember with a 5/8" diameter x 4 1/2" long bolt and nut. The third leg of the upper control arm extended forward and to the left of the rear axle and was attached to a bracket that was welded to the crossmember adjacent to the longitudinal frame rail. The control arm was attached to the bracket by a 5/8" diameter stud that was inserted approximately 1 3/4" into the crossmember. The stud was secured into the control arm by a 3/16" diameter roll pin that was positioned 1" inboard of the end of the control arm. The stud extended through the mounting bracket and was positioned by large rubber bushings and washers. A nut was threaded onto the end of the stud and tightened to secure the attachment point. The studded attachment point maintained lateral stability of the rear axle assembly.

The roll pin fractured which allowed the stud to separate from the control arm and fall from the vehicle. As a result, the rear axle was free to move laterally, thus producing lateral instability in the vehicle. The rear tires subsequently contacted the inner aspects of the wheel openings, which abraded the undercoating from the sheetmetal and deformed the inboard edges of the inner wheel openings. The tires also contacted the rear coil springs which were jacketed by vinyl (top 4 coils). The left rear tire scuffed the left coil spring jacket while the right rear tire

rubbed through the right vinyl spring covering. The abrasions to the coil spring coverings occurred as the wheels were rotating and the axle was shifting from side-to-side. The stud end of the upper control arm impacted the frame mounting bracket numerous times during the axle shift which produced circular gouges to the bracket.

The rear of the van was lifted off the ground while the control arm was still attached to the rear axle and forward crossmember. The axle assembly was easily shifted laterally 4-5" as it pivoted on the rubber bushings of the lower control arms.

The upper control arm was removed from the vehicle and forwarded to [REDACTED] for further examination. A metallurgist from the [REDACTED] examined the fractured roll pin. A report of his findings is included as Appendix B of this report.

The separated control arm stud was taken from the scene by the driver who forwarded it to her attorney. As of this report date, he has not shipped the stud to [REDACTED] for examination.

The rear bolt on the control arm required 150 ft. lbs. of torque to loosen the nut while the front mounted bolt and nut assembly required approximately 140 ft. lbs. of torque to loosen the nut. Torques were obtained from a one-half inch drive MAC tools torque wrench with a model number of [REDACTED].

SELECTED PRINTS



Pre-Event Trajectory Of The Ford Aerostar.



Rollover Trajectory Of The Ford Aerostar.



Shattered Side Or Backlight Glass On Median.



Final Rest Area Of The Ford Aerostar.



Lookback Views Of The Vehicle's Trajectory.



Left Front Three-Quarter View Of The Ford Aerostar.



Right Front Three-Quarter View.



Roof Deformations.



Side Views Of The Ford Aerostar.



Rear Undercarriage View Of The Ford Aerostar.



Tire Abrasions To The Inner Wall Of The Left Rear Wheel Housing.



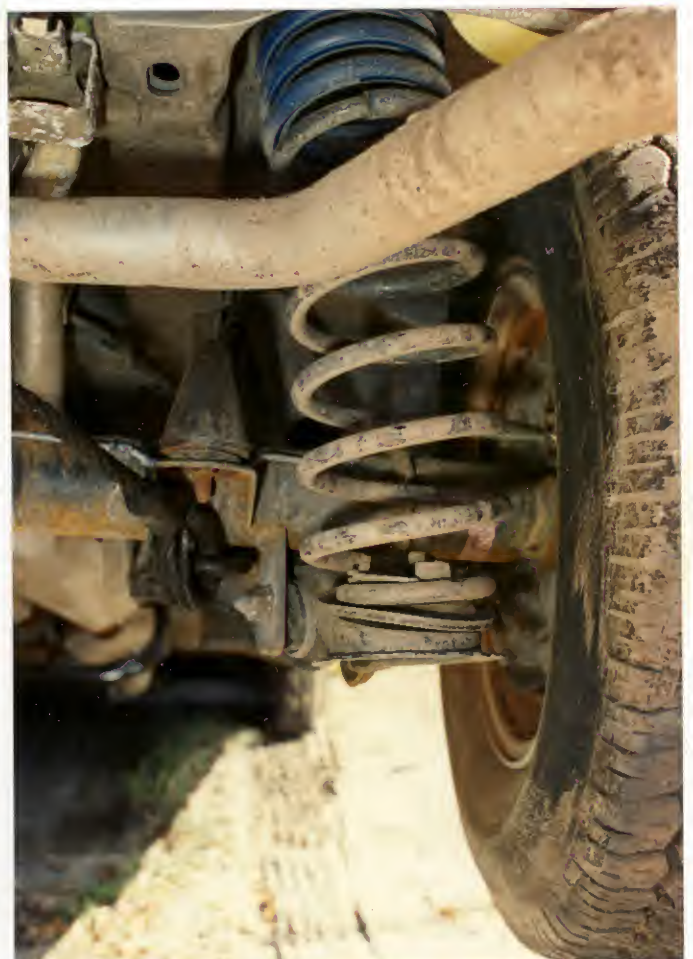
Tire Abrasions To The Vinyl Jacket On The Left Rear Coil Spring.



Tire Abrasions To The Right Rear Inner Wheel Housing.



Tire Abraded Jacket Of The Right Rear Coil Spring.



Left And Right Rear Coil Springs.



Left And Right Rear Lower Control Arms.



Upper Rear Control Arm: Fore And Aft Attachment Points.



Forward Bolt
Torqued At 140 Ft.Lbs.

Rear Axle Mounted Bolt
Torqued At 150 Ft.Lbs.



Rear Axle Attachment Point Of The Upper Control Arm.



Rearward View Of The Axle Attachment Point.



Additional View Of The Fore And Aft Mounting Points.



Forward Attachment Point Of The Rear Upper Control Arm To A Crossmember.



Separated Lateral Mount Of The Upper Control Arm.



Separated Lateral Mounting Point Of The Rear Upper Control Arm.



Closeup View Of The Stud Bore And Fractured 3/16" Diameter Roll Pin.



Control Arm Gouged The Lateral Mounting Bracket.



Interior View Of The Driver's Seat Position And The Non-Deployed Air Bag.



View Across The Interior Into The Right Front Occupant's Space.



Second Seat Area.



Third Seat Area.



Detached Left Rear Third Seat Lap Belt Buckle Assembly.

SLIDE INDEX

<u>Slide No(s).</u>	<u>Description</u>
1-5	Trajectory of the Ford Aerostar
6	Shattered side or backlight glass on grass median
7	Trajectory of the Aerostar
8	Blood stain on road surface, FRP of ejected occupant and van
9	Lookback view of vehicle's trajectory
10	Left front three-quarter view of the Aerostar
11	Left side view
12	Left rear three-quarter view
13	Rear view
14	Right side view
15	Right front three-quarter view
16	Vehicle identification label on left B-pillar
17	Rear undercarriage view
18	Tire abrasions to the left rear inner wheel housing
19	Tire abrasions to the left rear coil spring
20	Left rear coil spring
21	Tire abrasions to the right rear inner wheel housing
22	Tire abrasions to the right rear coil spring
23	Right rear coil spring
24, 25	Left rear suspension components
26-28	Right rear suspension components
29	Right rear lower control arm
30	Fore and aft mounting points of the upper rear control arm
31	Rear axle mount of the upper rear control arm

SLIDE INDEX (CONT'D.)

<u>Slide No(s).</u>	<u>Description</u>
32	Forward (crossmember) mount of the upper rear control arm
33, 34	Separated lateral mount of the upper rear control arm
35	Upper control arm impact damage to the mounting bracket
36, 37	3/16" diameter roll pin and 5/8" stud bore in the upper rear control arm
38	View across the interior from the right door area
39	Second seat area
40	Third seat area
41	Rear seats 3-point belt system
42	Lap belt attachment point
43	Belt buckled into the lap belt buckle assembly
44, 45	Forward views of the interior



CA 9205 #1



CA 9205 #2



CA 9205 #3



CA 9205 #4



CA 9205 #5



CA 9205 #6



CA 9205 #7



CA 9205 #8



CA 8205 #9



CA 9205 #10



CA 9205 #11



CA 9205 #12



CA 9205 #13



CA 9205 #14



CA 9205 #15



CA 9205 #16



CA9205 #17



CA9205 #18



CA9205 #19



CA 9205 #20



CA9205 #21



CA9205 #22



CA 9205 #23



CA 9205 #24



CA 8206 #25



CA 9205 #28



CA9205 #27



CA 9205 #28



CA 9205 #29



CA 9205 #30



CA 9205 #31



CA 9205 #32



CA 9205 #33



CA 9205 #34



CA 9205 #35



CA 9205 #38



CA 9205 #37



CA 9205 #38



CA 9205 #39



CA 9205 #40



CA 9205 #41



HEAVYWE

CA 9205 #42



CA9205 #43



CA 9205 #44



CA 9205 #45

APPENDIX A

Police Accident Report

DHPT USE ONLY -

ORIGINAL

SOUTH CAROLINA

UNIFORM TRAFFIC ACCIDENT REPORT
(FOR INVESTIGATING OFFICERS)
D.H.P.T. FORM TR-310 Rev. 5/90Amended: Attach Copy
of Original Report

Corrected

Page 1 of 1 Pages

Date	Time	County	1 Interstate 2 US Primary 3 SC Primary	4 Secondary 5 County 6 Other	ACCIDENT LOCATION Route Number and Name if any	0 Main Line 2 Alternate	AUXILIARY 5 Spur 6 Connection 7 Business	8 Bypass 9 Other
92	15	15			ON			
Lane	Ramp	Lane / Ramp Travel Direction	1 Interstate 2 US Primary 3 SC Primary	4 Secondary 5 County 6 Other	BASE INTERSECTION Route Number and Name if any	0 Main Line 2 Alternate	AUXILIARY 5 Spur 6 Connection 7 Business	8 Bypass 9 Other
1	1	N E S W			FROM			
Distance Offset .50 MILES FEET		Direction N E S W	1 Interstate 2 US Primary 3 SC Primary	4 Secondary 5 County 6 Other	SECOND INTERSECTION Route Number and Name if any	0 Main Line 2 Alternate	AUXILIARY 5 Spur 6 Connection 7 Business	8 Bypass 9 Other
RR Crossing					TOWARD			
Time Police Notified 1817	Time Police Arrived 1825	Time Ambulance Arrived 1830			City or Town	Or if Outside 4 Miles N E S W		For DHPT Use Only MP Grid

Unit #	Sex	Race	Driver or Pedestrian Full Name	Unit #	Sex	Race	Driver or Pedestrian Full Name
1	F	W	[REDACTED]				
Birth Date			Street or R.F.D.	Birth Date			Street or R.F.D.
65							
Residence County			City, State & Zip	Residence County			City, State & Zip
State	Class	Driver License Number	State	Class	Driver License Number		
NJ	D						
Year	Body	Make & Vehicle Identification Number	Year	Body	Make & Vehicle Identification Number		
92	VAN	FORD-1EMDA31UG6					
State	Year	License Plate Number	State	Year	License Plate Number		
PA	92						
Home Telephone		Owner's Full Name	Home Telephone		Owner's Full Name		
		Rental					
Bus Telephone		Street or R.F.D.	Bus Telephone		Street or R.F.D.		
Residence County		City, State & Zip	Residence County		City, State & Zip		

Contrib. to Acc. Yes No	Estimated Speed 65-70	Speed Limit 65	Hazardous Material	Contrib. to Acc. Yes No	Estimated Speed	Speed Limit	Hazardous Material
# of Occupants	Vehicle Towed by	Trl. Length	Trl. Width	# of Occupants	Vehicle Towed by	Trl. Length	Trl. Width
5							
Summons Number	Violation Codes			Summons Number	Violation Codes		

Direction of Travel Unit #1 N E S W Unit #2 N E S W	Describe What Happened (Refer to Units by Number): Vehicle #1 was traveling south on [REDACTED]. The driver of Vehicle #1 lost control of the vehicle causing it to overturn after running into the median.

NOTICE - THE UNIFORM TRAFFIC ACCIDENT REPORT IS FOR STATISTICAL REPORTING PURPOSES ONLY AND REFLECTS THE OFFICER'S BEST KNOWLEDGE, OPINION, AND BELIEF COVERING THE ACCIDENT BUT NO WARRANTY IS MADE AS TO THE FACTUAL ACCURACY THEREOF.

SPECIAL USE ONLY		Damage to Property Other Than Vehicle: \$	Estimated Amt. of Damage to Unit 1: \$19000.00	Estimated Amt. of Damage to Unit 2: \$
Witness Full Name	Address	Phone	Zip	Age
Property Owner Name	Address	Zip		

OCCUPANTS	1	F	W	26	11	12	1	3	Name	Driver Vehicle #1	Address	Zip
	1	M	W	27	13	12	1	1	Name	[REDACTED]	Address	Zip
	1	F	W	26	22	00	2	4	Name	[REDACTED]	Address	Zip
	1	F	W	26	31	00	2	4	Name	[REDACTED]	Address	Zip
	1	M	W	27	33	00	1	1	Name	[REDACTED]	Address	Zip
									Name	[REDACTED]	Address	Zip
Investigator's Name		Rank	Badge #	Agency Type	Code	Date	92	Reviewer's Name	Rank			

28

#9 FIRST HARMFUL EVENT**NON-COLLISION**

- 01 - OVERTURN
- 02 - FIRE/EXPLOSION
- 03 - BARRICADE
- 04 - GAS INHALATION
- 05 - THROWN OR FALLING OBJECT
- 06 - SPILL
- 09 - OTHER NON-COLLISION

COLLISION

- 10 - PEDESTRIAN

VEHICLE IN TRANSPORT

- 20 - OTHER
- 21 - HEAD ON
- 22 - REAR END
- 23 - ANGLE
- 24 - SIDE SWIPE
- 25 - BACKED INTO
- 30 - PARKED VEHICLE
- 31 - STOPPED VEHICLE
- 35 - RAILWAY TRAIN
- 40 - PEDALCYCLIST
- 41 - MOTORCYCLIST
- 42 - MOPED

ANIMAL

- 44 - DOMESTIC ANIMAL WITH RIDER
- 45 - DOMESTICATED
- 46 - WILD, OTHER THAN DEER
- 47 - DEER
- 48 - OTHER

FIXED OBJECT

- 51 - HIGHWAY GUARDRAIL
- 52 - IMPACT ATTENUATOR CRASH CUSHION
- 53 - UTILITY POLE
- 54 - LIGHT STANDARD
- 55 - TREE
- 56 - FIRE HYDRANT
- 57 - PIER OR COLUMN
- 58 - OVERHEAD SIGN SUPPORT
- 59 - HIGHWAY SIGN
- 60 - TRAFFIC SIGNAL POST
- 63 - BARRICADE
- 64 - HIGHWAY STRUCTURE, BRIDGE, OVERPASS
- 65 - CLUMPT MEADOW
- 66 - CLUMPT
- 67 - RETAINING WALL
- 68 - DIVIDER FOR CONCRETE OR STEEL
- 69 - ROCK OR STONE SLOPE
- 70 - EARTH SLOPE
- 71 - BUILDING
- 72 - FENCE, OTHER THAN MEDIAN
- 73 - BOULDER
- 74 - DITCH
- 75 - OVERHEAD STRUCTURE UNDERPASS
- 76 - OTHER FIXED OBJECT
- 77 - TRASH DUMPSTER

OTHER

- 80 - OTHER OBJECT (E. FOREIGN MATERIAL)
- 83 - ROAD DEFECT
- 89 - OTHER

#10 HARMFUL EVENT LOCATION**ON TRAFFICWAY****ON ROADWAY**

- 01 - AT INTERSECTION
- 02 - AT INTERSECTION IN CROSSWALK
- 03 - NONJUNCTION
- 04 - NONJUNCTION IN CROSSWALK
- 05 - ON ISLAND
- 06 - ON ISLAND CROSSWALK
- 07 - INTERCHANGE RAMP
- 09 - OTHER

OFF ROADWAY

- 21 - MEDIAN
- 22 - ISLAND
- 23 - SHOULDER, LEFT
- 24 - SHOULDER, RIGHT
- 25 - DRIVEWAY ACCESS
- 26 - DRIVEWAY ACCESS IN CROSSWALK
- 27 - ROADSIDE, LEFT
- 28 - ROADSIDE, RIGHT
- 29 - SIDEWALK, LEFT
- 30 - SIDEWALK, RIGHT
- 39 - OTHER

OFF TRAFFICWAY

- 41 - OUTSIDE TRAFFICWAY, LEFT
- 42 - OUTSIDE TRAFFICWAY, RIGHT

#11 PROBABLE CAUSE**DRIVER**

- 00 - UNDER THE INFLUENCE OF ALCOHOL AND DRUGS
- 01 - UNDER THE INFLUENCE OF DRUGS
- 02 - UNDER THE INFLUENCE OF ALCOHOL
- 03 - FAILED TO YIELD RIGHT OF WAY
- 04 - DESREGARDED TRAFFIC SIGNALS, SIGNALS
- 05 - EXCEEDED STATED SPEED LIMIT
- 06 - RAN OFF ROAD
- 07 - MADE AN IMPROPER TURN
- 08 - WRONG SIDE OR WRONG WAY
- 09 - FOLLOWED TOO CLOSELY
- 10 - IMPROPER LANE CHANGE
- 11 - IMPROPER BACKING OPERATION
- 12 - IMPROPER PASSING
- 13 - IMPROPER SIGNAL
- 14 - IMPROPER PARKING
- 15 - FELL ASLEEP, FARMED, ETC.
- 16 - DID NOT COMPLY WITH LICENSE RESTRICTION
- 17 - HANDICAPPED
- 18 - INATTENTION
- 19 - OTHER

ENVIRONMENT

- 20 - SMOKE
- 21 - FOG, SMOG
- 22 - SLEET, RAIN
- 23 - BLOWING SAND, SOIL, DIRT
- 24 - SEVERE CROSSWINDS
- 25 - RAIN, SNOW
- 26 - SIGN DESTRUCTION
- 27 - VEGETATION DESTRUCTION
- 28 - SNOW BANK DESTRUCTION
- 29 - HILL OBSTRUCTION
- 30 - BUILDING OBSTRUCTION
- 31 - CURVE IN ROADWAY
- 32 - ANIMAL IN ROADWAY
- 39 - OTHER

OTHER PERSON (NOT A DRIVER OR PASSENGER)

- 40 - UNDER THE INFLUENCE OF ALCOHOL AND DRUGS
- 41 - UNDER THE INFLUENCE OF DRUGS
- 42 - UNDER THE INFLUENCE OF ALCOHOL
- 43 - FAILED TO YIELD RIGHT OF WAY
- 44 - DESREGARDED TRAFFIC CONTROL DEVICE
- 45 - ILLEGALLY IN ROADWAY
- 46 - BICYCLE VIOLATION
- 47 - CLOTHING NOT VISIBLE
- 48 - OTHER

PASSENGER

- 51 - PASSENGER UNDER THE INFLUENCE OF DRUGS
- 52 - PASSENGER UNDER THE INFLUENCE OF ALCOHOL
- 53 - PASSENGER OBSTRUCTED DRIVER'S VIEW
- 54 - FELL OFF VEHICLE
- 59 - OTHER

ROAD

- 61 - WET
- 62 - ICY
- 63 - SLUSHY
- 64 - DEBRIS
- 65 - RUTS, HOLES, BUMPS
- 66 - ROAD UNDER CONSTRUCTION/MAINTENANCE
- 67 - WORN TRAVEL-POLISHED SURFACE
- 68 - OBSTRUCTION
- 69 - TRAFFIC CONTROL DEVICE INOPERATIVE
- 70 - SHOULDERS LOW, SOFT, OR HIGH
- 79 - OTHER

VEHICLE

- 81 - BRAKE
- 82 - STEERING
- 83 - POWER PLANT
- 84 - SUSPENSION
- 85 - TIRES
- 86 - EXHAUST
- 87 - LIGHTS
- 88 - SIGNALS
- 89 - WINDOWS/WINDSHIELD
- 90 - RESTRAINT SYSTEMS
- 91 - WHEELS
- 92 - TRUCK COUPLING
- 93 - CARGO
- 94 - FIRE
- 95 - JACK-KNIFE

OTHER

- 99 - OTHER

#32 & 33 DRIVER INTENTIONS**TRAFFIC UNIT MANEUVERING FOR TRAFFIC CONTROLS INTERSECTIONS OR RAILROAD CROSSINGS:**

- 00 - NO EXTERNAL CAUSE OF MANUEVER
- 01 - TRAFFIC SIGNAL
- 02 - STOP SIGN
- 03 - YIELD SIGN
- 04 - UNCONTROLLED INTERSECTION
- 05 - CROSSWALK NOT AT INTERSECTION
- 06 - POLICE OFFICER, SCHOOL CROSSING GUARD, ETC.
- 07 - RAILROAD CROSSING
- 08 - RAILROAD CROSSING FLASHER OR GATE
- 09 - OTHER CONTROL

TRAFFIC UNIT MANEUVERING OR AVOIDING SOMETHING IN ROADWAY:

- 10 - PEDESTRIAN
- 11 - PEDALCYCLE
- 12 - OTHER ROAD VEHICLE (EXCEPT PEDALCYCLE)
- 13 - OTHER VEHICLE
- 14 - ANIMAL
- 15 - FOREIGN OBJECT IN ROADWAY
- 16 - WATER, ICE, SNOW, OR HAZARDOUS SUBSTANCE ON ROAD
- 17 - ROAD DEFECT
- 18 - ROAD MAINTENANCE OR CONSTRUCTION WORK
- 19 - FIXED OBJECT OR STRUCTURE
- 20 - FOG, SMOKE, OR DUST
- 21 - PREVIOUS ACCIDENT
- 22 - OTHER EVENT
- 23 - CURVE IN ROADWAY
- 24 - RESTRICTION IN ROADWAY WIDTH
- 25 - CHANGE IN ROADWAY ALIGNMENT
- 26 - SHOULDER
- 27 - LOOSE GRAVEL IN ROADWAY
- 28 - UNKNOWN OBJECT, EVENT, OR FEATURE

TRAFFIC UNIT MANUEVER BECAUSE OF MECHANICAL FAILURE:

- 29 - TIRE FAILURE
- 30 - STEERING GEAR FAILURE
- 31 - ENGINE FAILURE
- 32 - WINDSHIELD WIPER FAILURE
- 33 - LOAD SPILLED OR DROPPED
- 34 - INVOLVED IN PREVIOUS ACCIDENT
- 35 - OTHER FAILURE

TRAFFIC UNIT MANUEVER FOR OWN INTENDED MOVEMENT:

- 36 - MOVING STRAIGHT AHEAD IN PROPER DIRECTION, INCLUDING CURVES IN ROADWAY
- 37 - MERGE WITH TRAFFIC ON LEFT
- 38 - MERGE WITH TRAFFIC ON RIGHT
- 39 - LEFT TURN
- 40 - RIGHT TURN
- 41 - U TURN
- 42 - ENTER ROADWAY FROM ENTRANCE RAMP ON LEFT
- 43 - ENTER ROADWAY FROM ENTRANCE RAMP ON RIGHT
- 44 - ENTER ROADWAY FROM SHOULDER ON LEFT
- 45 - ENTER ROADWAY FROM SHOULDER ON RIGHT
- 46 - ENTER ROADWAY FROM PARKING AT LEFT CURB
- 47 - ENTER ROADWAY FROM PARKING AT RIGHT CURB
- 48 - LEAVE ROADWAY TO EXIT RAMP ON LEFT
- 49 - LEAVE ROADWAY TO EXIT RAMP ON RIGHT
- 50 - LEAVE ROADWAY TO SHOULDER ON LEFT
- 51 - LEAVE ROADWAY TO SHOULDER ON RIGHT
- 52 - LEAVE ROADWAY TO PARKING AT LEFT CURB
- 53 - LEAVE ROADWAY TO PARKING AT RIGHT CURB
- 54 - LEAVE ROADWAY TO DRIVEWAY ON LEFT
- 55 - LEAVE ROADWAY TO DRIVEWAY ON RIGHT
- 56 - BOARD OR DISCHARGE PASSENGER
- 80 - BACKING

TRAFFIC UNIT MANUEVER AROUND OTHER TRAFFIC UNIT(S):

- 57 - OVERTAKING SUBJECT UNIT ON LEFT
- 58 - OVERTAKING SUBJECT UNIT ON RIGHT
- 59 - CHANGING LANES TO LEFT
- 60 - CHANGING LANES TO RIGHT
- 61 - MERGING FROM LEFT
- 62 - MERGING FROM RIGHT
- 63 - ON RIGHT SIDE OF ROADWAY
- 64 - IN WRONG DIRECTION ON ONE WAY ROADWAY
- 65 - SWERVING TO LEFT
- 66 - SWERVING TO RIGHT
- 67 - SLOWING OR STOPPING
- 68 - STOPPED IN TRAFFIC
- 69 - STOPPED TO BOARD OR DISCHARGE PASSENGER
- 70 - SKIDDING, SPINNING, OR YAWING
- 71 - JACK KNIFE
- 72 - TURNING LEFT FROM SAME DIRECTION
- 73 - TURNING LEFT FROM OPPOSITE DIRECTION
- 74 - MAKING U TURN
- 75 - TURNING RIGHT FROM SAME DIRECTION
- 76 - TURNING RIGHT FROM OPPOSITE DIRECTION
- 77 - ENTERING ROADWAY FROM RAMP ON LEFT
- 78 - ENTERING ROADWAY FROM RAMP ON RIGHT
- 79 - ENTERING ROADWAY FROM ROADWAY ON LEFT

#34 & 35 VEHICLE MANUEVER**MOVEMENTS ESSENTIALLY STRAIGHT AHEAD**

- 00 - MOVING STRAIGHT, DETAILS UNKNOWN
- 01 - STRAIGHT AHEAD IN PROPER DIRECTION, INCLUDING CURVES IN ROADWAY
- 02 - OVERTAKING OTHER VEHICLE ON LEFT, LEFT OF CENTER LINE
- 03 - OVERTAKING OTHER VEHICLE ON LEFT, RIGHT OF CENTER LINE (JUST ON ONE WAY TRAFFIC)
- 04 - OVERTAKING ANOTHER VEHICLE ON RIGHT
- 05 - STRAIGHT AHEAD IN LEFT TURN LANE
- 06 - STRAIGHT AHEAD IN RIGHT TURN LANE
- 07 - CHANGING LANES TO LEFT
- 08 - CHANGING LANES TO RIGHT
- 09 - MERGING FROM LEFT (ROADWAY NARROWS ON LEFT)
- 10 - MERGING FROM RIGHT (ROADWAY NARROWS ON RIGHT)
- 11 - ON WRONG SIDE OF ROADWAY
- 12 - IN WRONG DIRECTION ON ONE WAY ROADWAY
- 13 - SWERVING TO LEFT
- 14 - SWERVING TO RIGHT
- 15 - SLOWING OR STOPPING
- 16 - SKIDDING LONGITUDINALLY
- 17 - SKIDDING LATRALLY
- 18 - SPINNING OR YAWING
- 19 - JACK KNIFE
- 20 - STOPPED IN TRAFFIC
- 21 - STARTING FROM STOP
- 22 - INCREASED SPEED

TURNING MOVEMENTS

- 30 - TURNING, DETAILS UNKNOWN
- 31 - LEFT FROM LEFT TURN BAY
- 32 - LEFT FROM LEFT (PROPER) LANE
- 33 - LEFT FROM OTHER LANE, LEGAL
- 34 - LEFT FROM OTHER LANE, ILLEGAL
- 35 - LEFT FROM UNKNOWN LANE
- 36 - U TURN
- 37 - RIGHT FROM SPECIAL LANE
- 38 - RIGHT FROM RIGHT (PROPER) LANE
- 39 - RIGHT FROM OTHER LANE, LEGAL
- 40 - RIGHT FROM OTHER LANE, ILLEGAL
- 41 - RIGHT FROM UNKNOWN LANE

ENTERING TRAFFIC LANE

- 50 - ENTERING TRAFFIC LANE, DETAILS UNKNOWN
- 51 - FROM ENTRANCE RAMP ON LEFT
- 52 - FROM ENTRANCE RAMP ON RIGHT
- 53 - FROM SHOULDER ON LEFT
- 54 - FROM SHOULDER ON RIGHT
- 55 - FROM PARKING SPACE AT LEFT CURB
- 56 - FROM PARKING SPACE AT RIGHT CURB
- 57 - FROM DRIVEWAY ON LEFT
- 58 - FROM DRIVEWAY ON RIGHT

LEAVING TRAFFIC LANE

- 60 - LEAVING TRAFFIC LANE, DETAILS UNKNOWN
- 61 - TO EXIT RAMP ON LEFT

- 62 - TO EXIT RAMP ON RIGHT
- 63 - TO SHOULDER ON LEFT
- 64 - TO SHOULDER ON RIGHT
- 65 - TO PARKING SPACE AT LEFT CURB
- 66 - TO PARKING SPACE AT RIGHT CURB
- 67 - TO DRIVEWAY ON LEFT
- 68 - TO DRIVEWAY ON RIGHT

PARKING ON OR ADJACENT TO TRAFFIC LANE

- 70 - PARKING, DETAILS UNKNOWN
- 71 - ON LEFT SHOULDER
- 72 - ON RIGHT SHOULDER
- 73 - AT LEFT CURB
- 74 - AT RIGHT CURB
- 75 - IN TRAFFIC LANE ON LEFT (RURAL)
- 76 - IN TRAFFIC LANE ON RIGHT (RURAL)
- 77 - DOUBLE PARKED ON LEFT
- 78 - DOUBLE PARKED ON RIGHT

MISCELLANEOUS MOVEMENTS

- 80 - OTHER MISCELLANEOUS, DETAILS UNKNOWN
- 81 - BACKING IN ROADWAY
- 82 - BACKING FROM ANGLE, PARKING ON LEFT
- 83 - BACKING FROM ANGLE, PARKING ON RIGHT
- 84 - BACKING ACROSS TRAFFIC
- 85 - BACKING ON SHOULDER
- 86 - VEHICLE PUSHED BY OTHER VEHICLE
- 87 - VEHICLE PUSHED BY PEDESTRIAN
- 88 - DRIVERLESS VEHICLE IN MOTION
- 89 - NOT IN MOTION (PARKED, ABANDONED, OR STANDING)
- 99 - UNKNOWN

OFFENSE

BEST AVAILABLE COPY

DRIVERS LICENSE VIOLATIONS		UNLAWFUL WEAPON	94
VIO. D. L. RESTRICTION	87	INTERFERRING WITH P/O SER. PRO	94
NO DRIVERS LICENSE IN POSS.	87	DIS. FIREWORKS FR MTR VEH	94
FAIL TO SURRENDER D. L.	87	REMOVE OR DEFACE TRAFF. SIGN	94
NO DRIVERS LICENSE	87	PARTIES TO A CRIME	94
CHILD OR WARD OPER. MTR. VEH.	87	FAIL TO STOP FOR POLICE VEH.	82
ALTERING DRIVERS LICENSE	87	SIGNS PERMITTED ON INTERSTATE	94
BORROWING OR LENDING D. L.	87	DAMAGING HWY	94
FALSE AFFIDAVIT (D.L.)	87	PLACE GLASS, NAILS, ETC. ON HW	94
DRIV. UNDER SUS. (FIXED PER.)	96	OBSTRUCT OF HWY BY RR CARS, E	94
DRIV. UNDER SUS. (SR-22)	96	DRINKING LIQUORS-PUBLIC CONV.	94
		BROWN BAGGING	94
		RESISTING ARREST	
VEHICLE LICENSE/INSURANCE VIOLATION			
FALSE AFFIDAVIT (UNINSUR VEH)	89	BUSES, TRUCKS, TRAILERS	
OPER. OR ALLOW. UNINS. VEH.	17	FAIL TO DISP. FUEL TAX MARK	95
NO VEHICLE LIC.	89	LOADS TO BE FIRMLY ATTACHED	94
NO. VEHICLE LIC.	89	OVER WIDTH VEH.	83
FAIL TO DISPLAY LICENSE	89	OVER HEIGHT	83
FAIL TO TRANSFER OWNERSHIP	89	OVER LENGTH	83
IMPROPER VEHICLE LIC.	90	PROJECTING LOAD	94
IMPROPER USE OF DEALER LIC.	89	SPELLING LOADS	94
		OVER WEIGHT (AXLE)	83
MOVING VIOLATIONS		OVER WEIGHT (GROSS)	83
IMPROPER BACKING	11	OVER WEIGHT (LICENSE)	83
SPEEDING (55 ZONE)	21	NO CLEARANCE LIGHTS OR REFL.	26
TOO FAST FOR CONDITIONS	21	NO LIGHT OR FLAG PROJ. LOAD	92
CHANGING LANES UNLAWFULLY	22	WARNING DEVICES (TRUCKS)	94
IMPROPER PARKING	23	WARNING DEVICES WHEN DISABLED	94
IMPROPER PARKING (NO PARK SN)	23	POLES DRAGGING ON HWY.	94
FAIL TO DIM HEADLIGHTS	25		
DRIVING WITHOUT LIGHTS	26	OTHER VIOLATIONS	
IMPROPER LIGHTS (FRONT)	26	DUMPING TRASH ON HWY/PRIV PRO	94
IMPROPER LIGHTS (REAR)	26	INDECENT EXPOSURE	94
REFLECTORS ON PASS. CAR	26	DISORDERLY CONDUCT	86
STOP LAMPS REQUIRED	26	IMPERSONATION OF LAW ENF. OFF.	94
LIGHTS ON OTHER VEHICLE	26	UNLAWFUL PISTOL	85
LIMIT ON NUMBER FRONT LIGHTS	26	POSS. OF SAWED-OFF SHOTGUN ET	94
DEFECTIVE BRAKES	28		
SPEEDING (55 ZONE)	41	EQUIPMENT VIOLATIONS	
TOO FAST FOR CONDITIONS	41	HELMETS: OPER. AND PASS.	94
DISREGARDING STOP SIGN	42	GOGGLES OR FACE SHIELD REQU.	94
DISREGARDING TRAFFIC SIGNAL	42	DRIVING UNSAFE VEHICLE	94
RIGHT TURN ON RED	42	MUFFLER VIOLATION	92
FAIL TO GIVE PROPER SIGNAL	44	UNSAFE EQUIPMENT	92
FAIL TO YIELD RW (NO SIGN)	44	VIO. VEH. INSPECTION LAW	79
FAIL TO YIELD RW (LEFT TURN)	44		
FAIL TO YIELD RW (STOP INT.)	44	INVESTIGATING AGENCY TYPE CODE	
FAIL TO YIELD RW (AT SIGN)	44		
FAIL TO YIELD RW (PRIV. ROAD)	44	NOT STATED OR UNKNOWN	1
DRIVING LEFT OF CENTER	45	STATE POLICE OR PATROL	1
DRIVING WRONG SIDE DIV. HWY.	45	COUNTY POLICE	2
IMPROPER PASSING	45	SHERIFF DEPARTMENT	3
IMPROPER PASSING (YELLOW LINE)	46	MUNICIPAL/CITY POLICE	4
HOUSE TRAILER SPEEDING	47	FEDERAL OR MILITARY POLICE	5
MAKING U TURN DIVIDED HWY	47	OTHER POLICY AGENCY	6
IMPROPER TURNING (LEFT OR RT)	47	PUBLIC UTILITIES COMMISSION	7
IMPROPER TURNING (CRV OR GRD)	47	OR PUBLIC SERVICE COMMISSION	
GEN. RULE TURNING MOVEMENT	47	NON-LAW ENFORCEMENT AGENCY	8
FOLLOWING TO CLOSELY (AUTO)	48		
FOLLOWING TO CLOSELY (TRUCKS)	48		
DISOBEDIENCE TO POLICE OFF	43		
RECKLESS DRIVING	61		
PASSING STOPPED SCHOOL PASSIN	62		
LEAVING SCENE OF ACC. (PO)	63		
LEAVING SCENE OF ACC. (PI)	94		
FAIL TO REPORT ACC. (PI)	94		
FAIL TO REPORT ACC. (PO)	94		
MOTOR DRIVEN CYCLE-SPEEDING	82		
CROSSING MEDIAN OR OTHER SEP	94		
PROJECTING LOAD (PASS. VEH)	94		
UNLAWFUL USE OF SPOT LIGHT	94		
MINIMUM SPEED LAW	97		
RACING ON PUBLIC ROADS	98		
ACQUIESCING IN RACING	98		
DRIVING UNDER INFLUENCE	99		

APPENDIX B

NTSB Metallurgical Report

Metallurgical Review of a Rear Upper Control Arm
Supplement to Calspan #92-05

[REDACTED]
Research Mechanical Engineer
NHTSA Special Crash Investigations
[REDACTED] 1992

**Metallurgical Review of a Rear Upper Control Arm
Supplement to Calspan #92-05**

BACKGROUND: A 1992 Ford Aerostar was involved in a single vehicle loss of control crash in which one of the three fasteners securing the rear upper control arm to the vehicle is alleged to have failed and separated from the vehicle prior to the vehicle losing control.

A truck driver, who was following the Aerostar, noted something falling from the rear of the Aerostar as the vehicle began to fishtail in its lane and subsequently roll over. Two unrestrained vehicle occupants were ejected through damaged glazing and sustained fatal injuries.

Figure 1 is a view of the subject vehicle's rear upper control arm. The top surface of the arm was stamped with the following codes:

[REDACTED]
FORD [REDACTED]

Figures 2 and 3 show the three attachment locations for the control arm. In particular, Figure 3 shows the separation of the control arm from its "frame" attachment point (location "C"). The control arm is attached to the "frame" at location "C" by a stud which passes through the frame flange and is held in place by a nut. The other end of the stud is located within the bored-out end of the control arm (Figure 4) and held in place by a roll pin.

EXAMINATION: The rear upper control arm was examined on [REDACTED] 1992 at the NTSB Metallurgical Laboratory in [REDACTED], and the following discussion is based upon the results of that examination.

As shown in Figure 4, location "C" of the control arm is drilled/bored for insertion of the stud. The 0.75" stud hole clearly showed original circumferential machining marks with no evidence of an interference type fit between the stud and hole.

As shown in Figure 4, the right edge of the stud hole was curled, with no corresponding damage to the left edge of the hole. In addition, there were two severe gouges initiating from the two points where the roll pin transects the "stud hole" and proceeding in a linear manner (as opposed to a spiral) to the outer edge of the stud hole (Figure 5). Both of these gouges are visible to the naked eye and marked in Figure 6. Based upon this evidence, it is unlikely that the stud gradually worked its way out of the hole, but rather suddenly exited the hole.

Upon examination of the two broken roll pin pieces while they were located within their original positions, an [REDACTED] Materials Engineer indicated that the fractured surfaces were indicative of a typical ductile overstress, with no evidence of fatigue or progressive cracking (Figure 7).

The top and bottom roll pin pieces were removed and examined (Figures 8 and 9), and the original findings of ductile overstress confirmed. The small amount of oxidation visible on the bottom roll pin piece did not appear to be the result of long term exposure. In addition, the irregular planes on the surface of both fractured roll pin pieces are indicative of secondary bending stresses. Such bending stresses would be expected considering the lack of evidence of an interference-type fit between the stud and hole.

The top roll pin piece was then examined with a scanning electron microscope at a magnification level of up to 3340X (Figure 10). When viewing the surface under this additional magnification, an NTSB Materials Engineer stated that the surface is characteristic of ductile overstress, with evidence of secondary bending stress, and the roll pin is made from common carbon steel.

CONCLUSIONS: Based upon a metallurgical review of the failed rear upper control arm, the roll pin pieces appear to have failed due to ductile overstress.

FIGURE 1: Subject rear upper
control arm

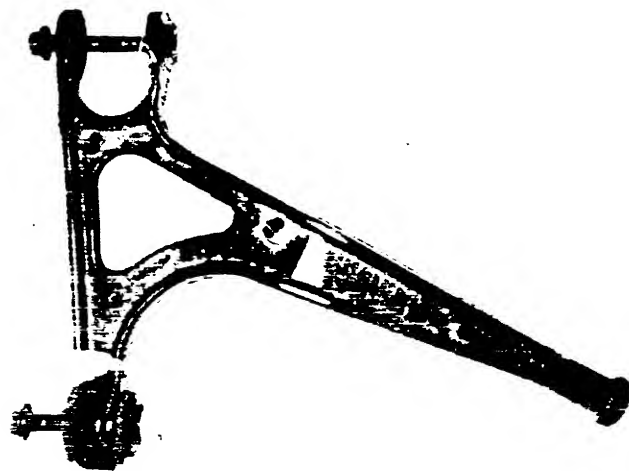
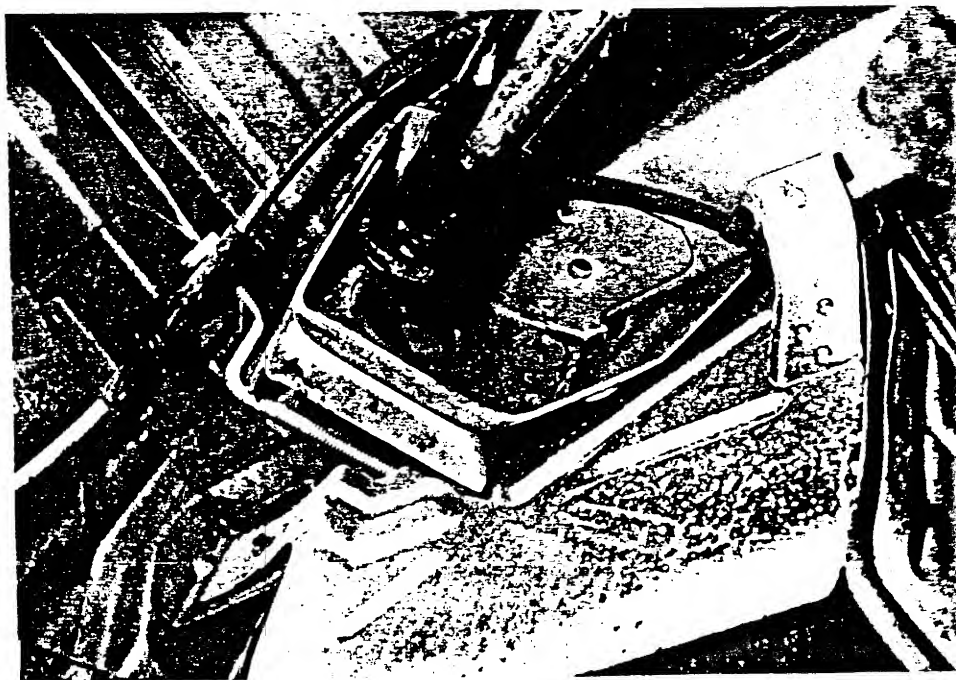


FIGURE 2: Control arm attachment
locations A & B



FIGURE 3: Control arm attachment
location C



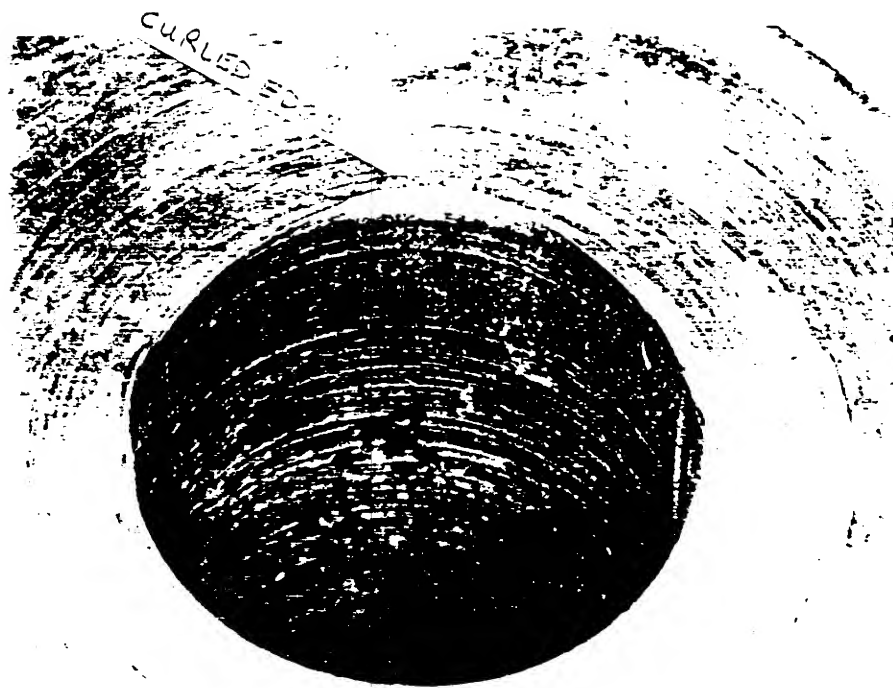


FIGURE 4: Machined end of the
control arm (location C)

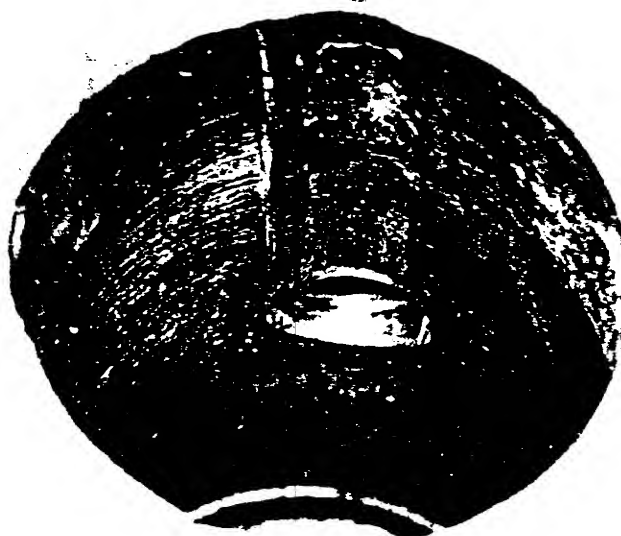


FIGURE 5: Gouging produced by the
top roll pin piece

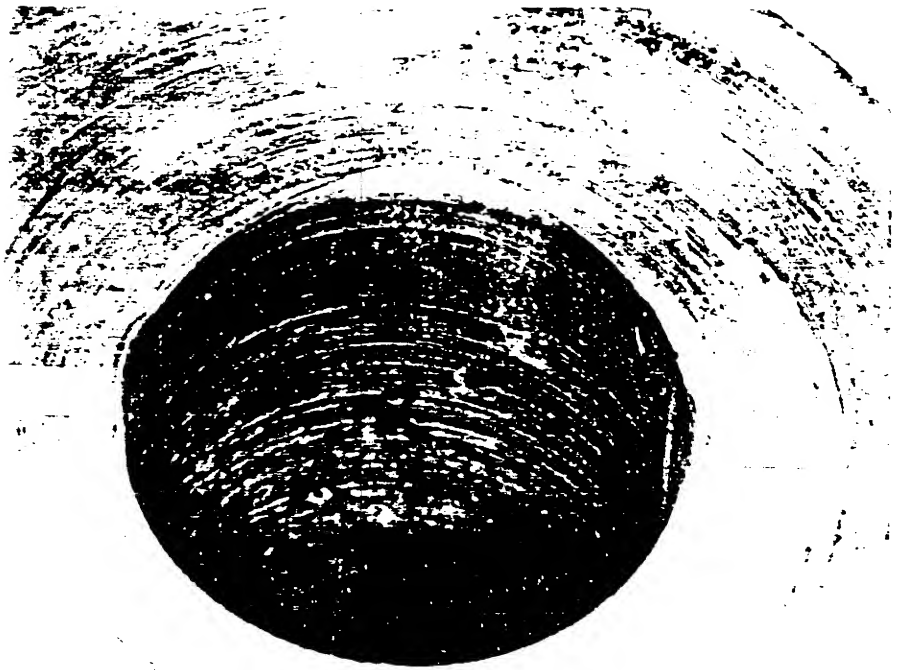
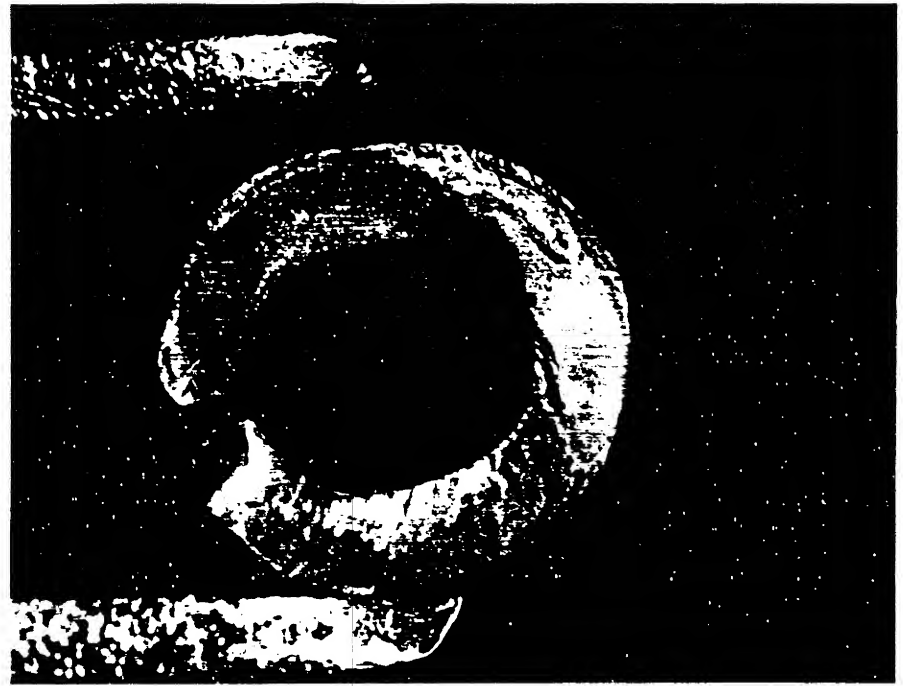


FIGURE 6: End of control arm with
corresponding gouging



FIGURE 7: Top roll pin piece in
its original position

Top pin x17



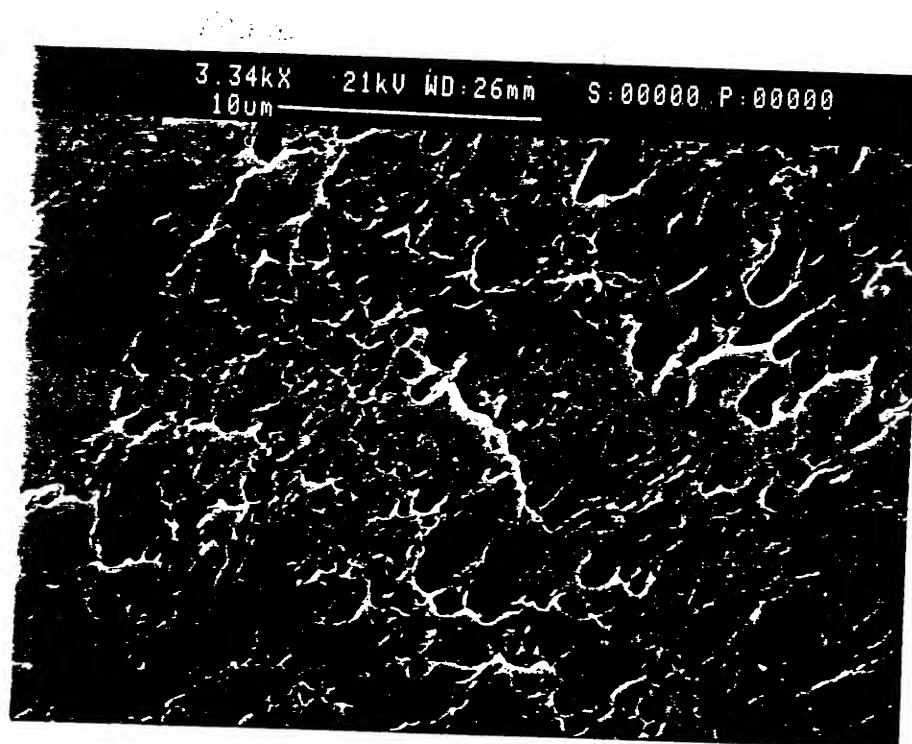
Top PIN

FIGURE 8: Top roll pin piece



Bottom PIN

FIGURE 9: Bottom roll pin piece



Overstress Region

FIGURE 10: Top roll pin piece at
a magnification of up
to 3340X